FIG. 1

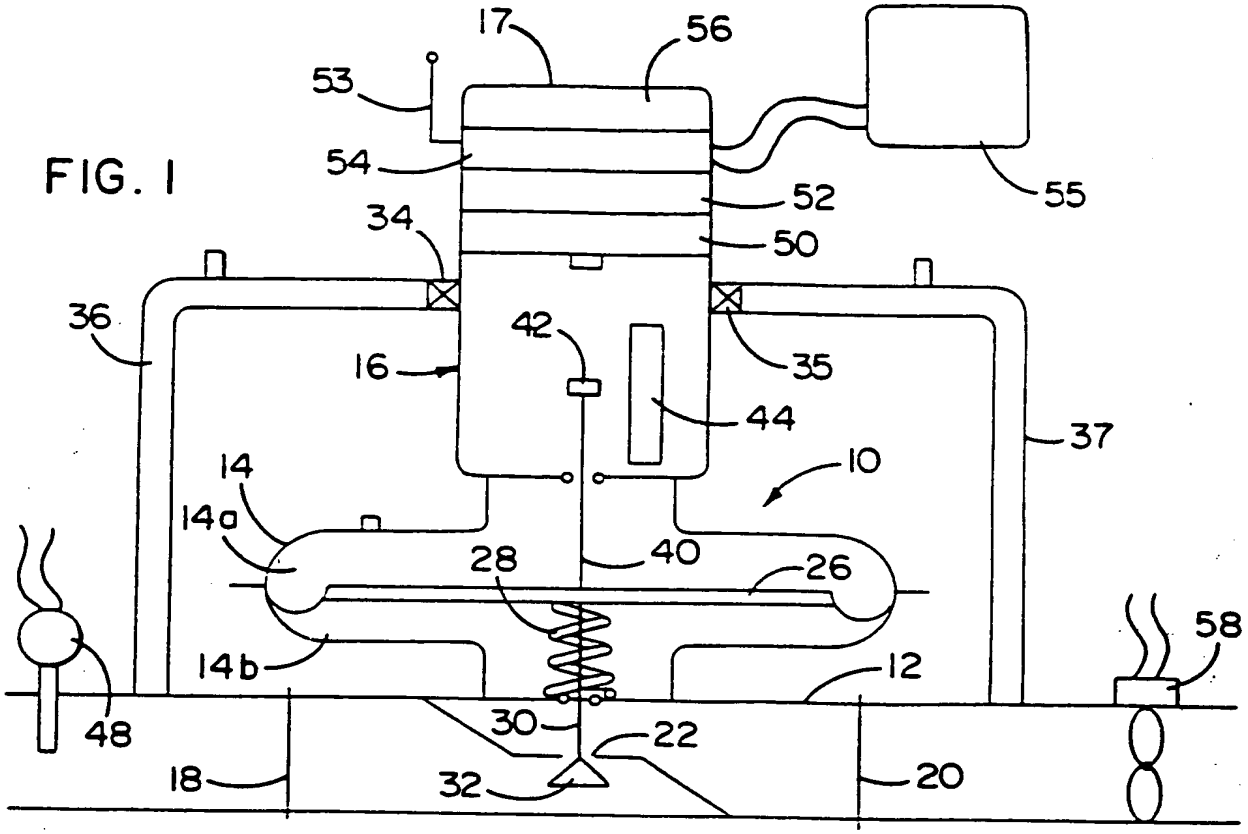
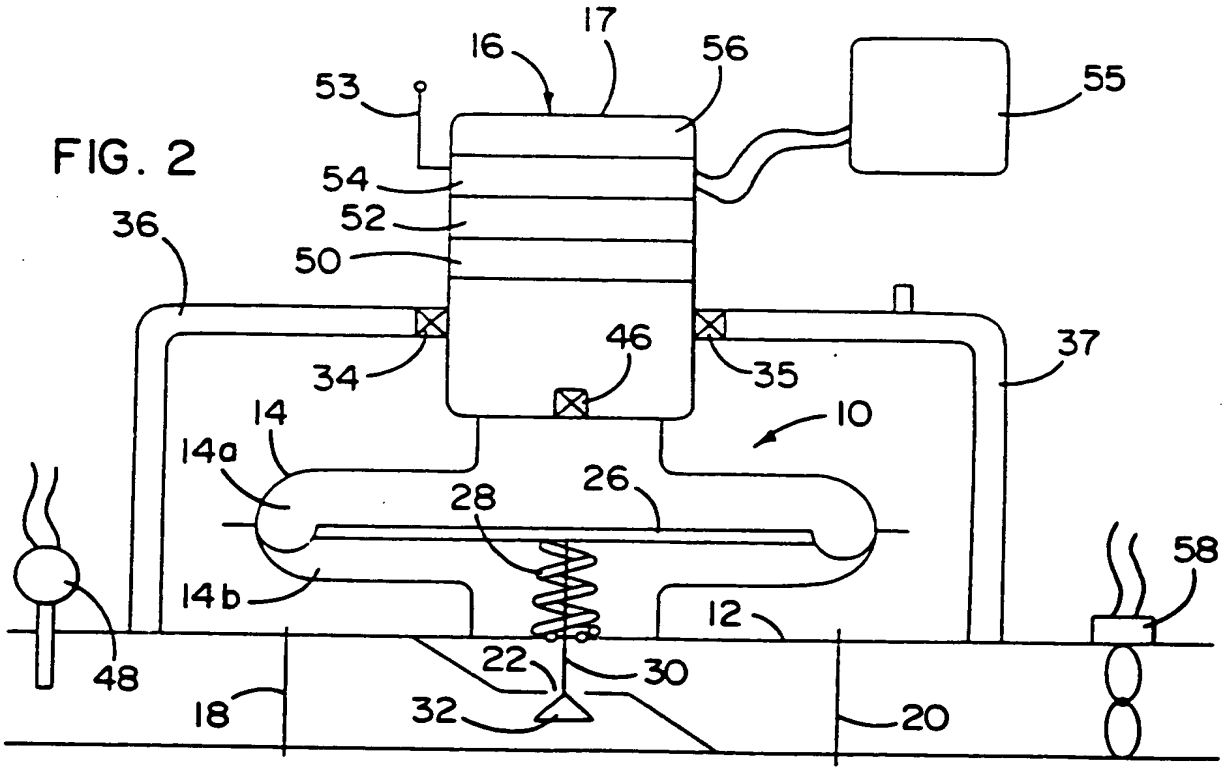

17
56
53
54
52
55
50
34
36
42
16
35
44
37
14
10
14a
40
28
26
58
14b
12
48
30
22
18
32
20

FIG. 2


16
17
56
53
55
54
52
36
50
46
37
34
35
14
10
14a
26
28
58
14b
12
48
22
30
18
32
20

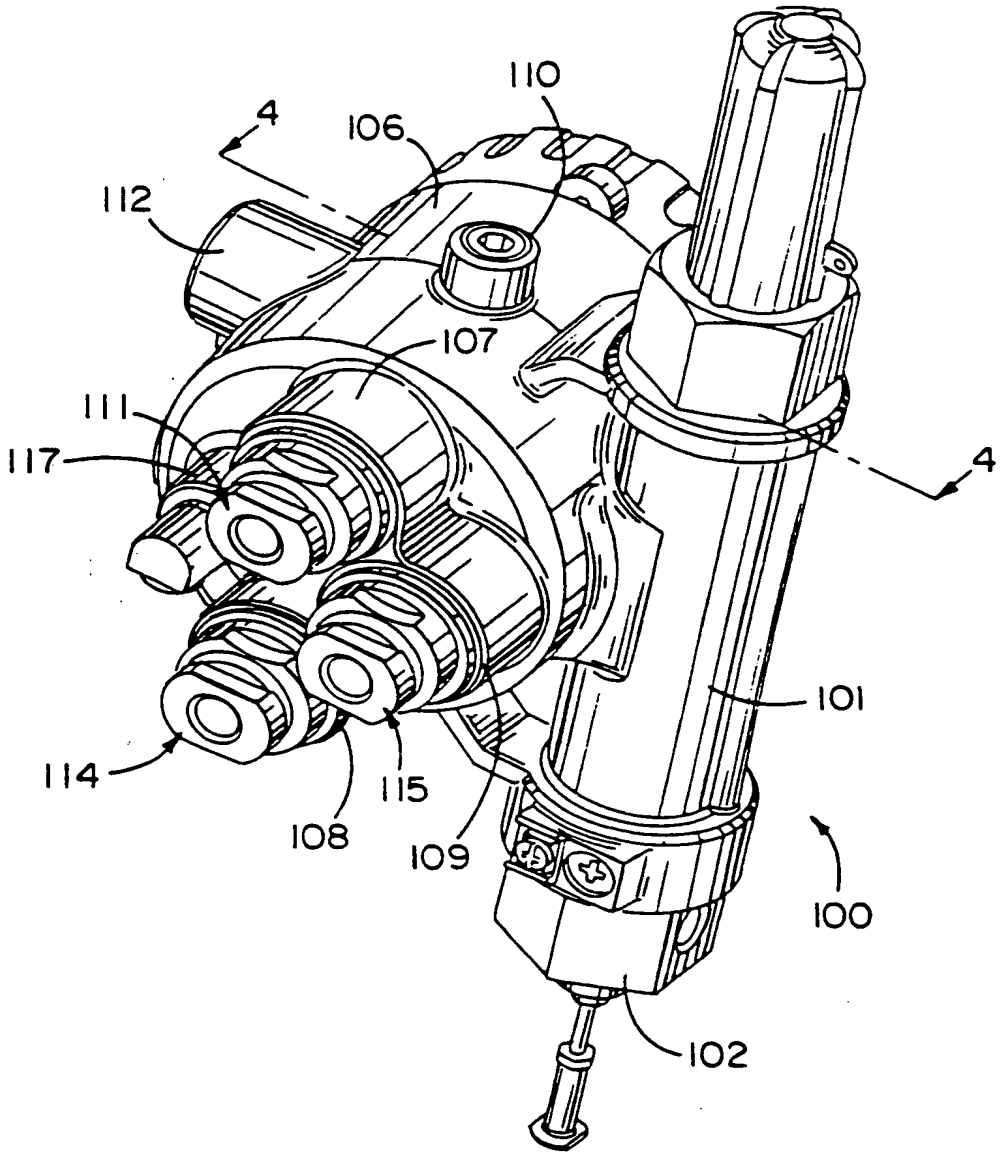


FIG. 3

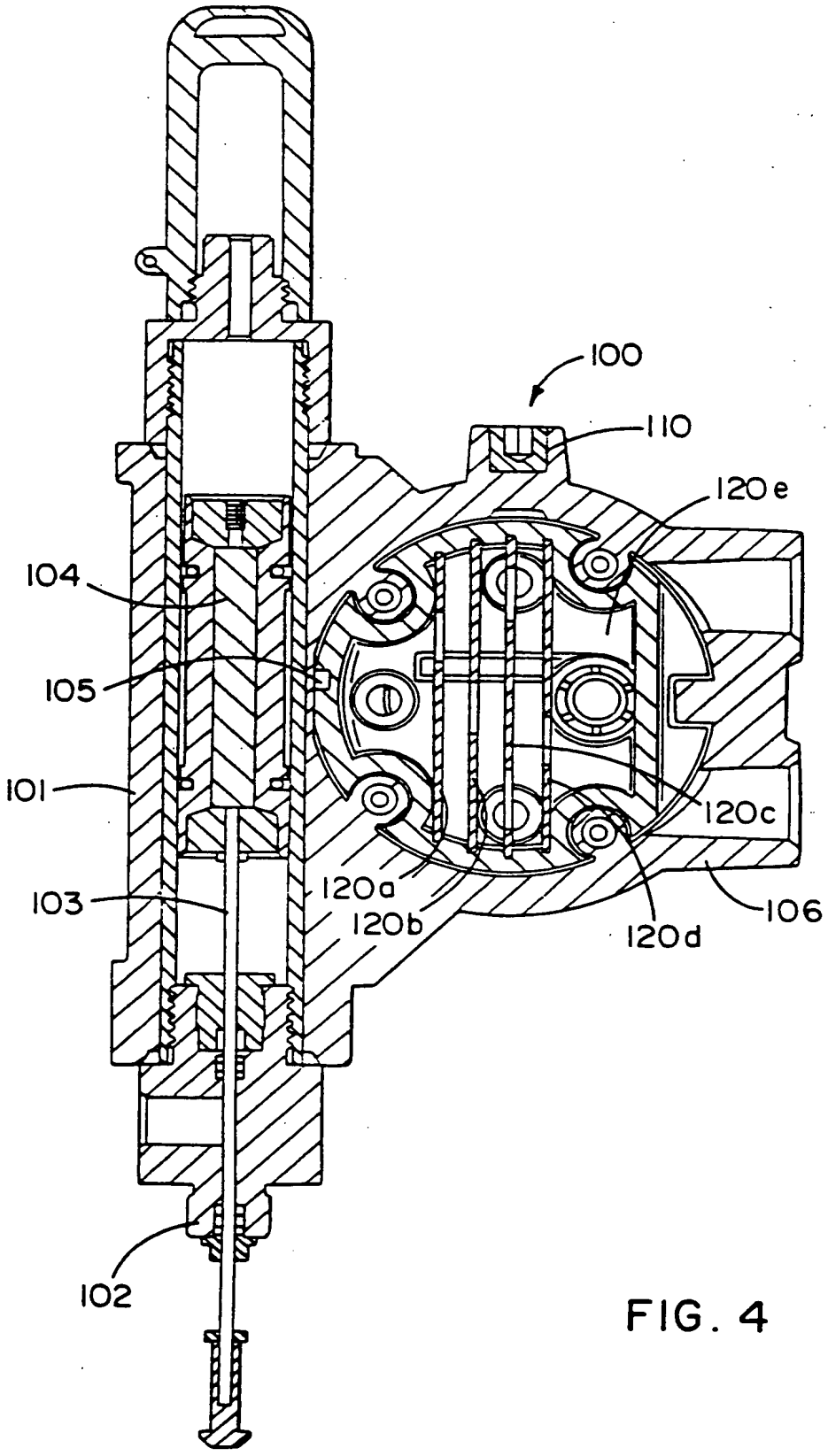


FIG. 4

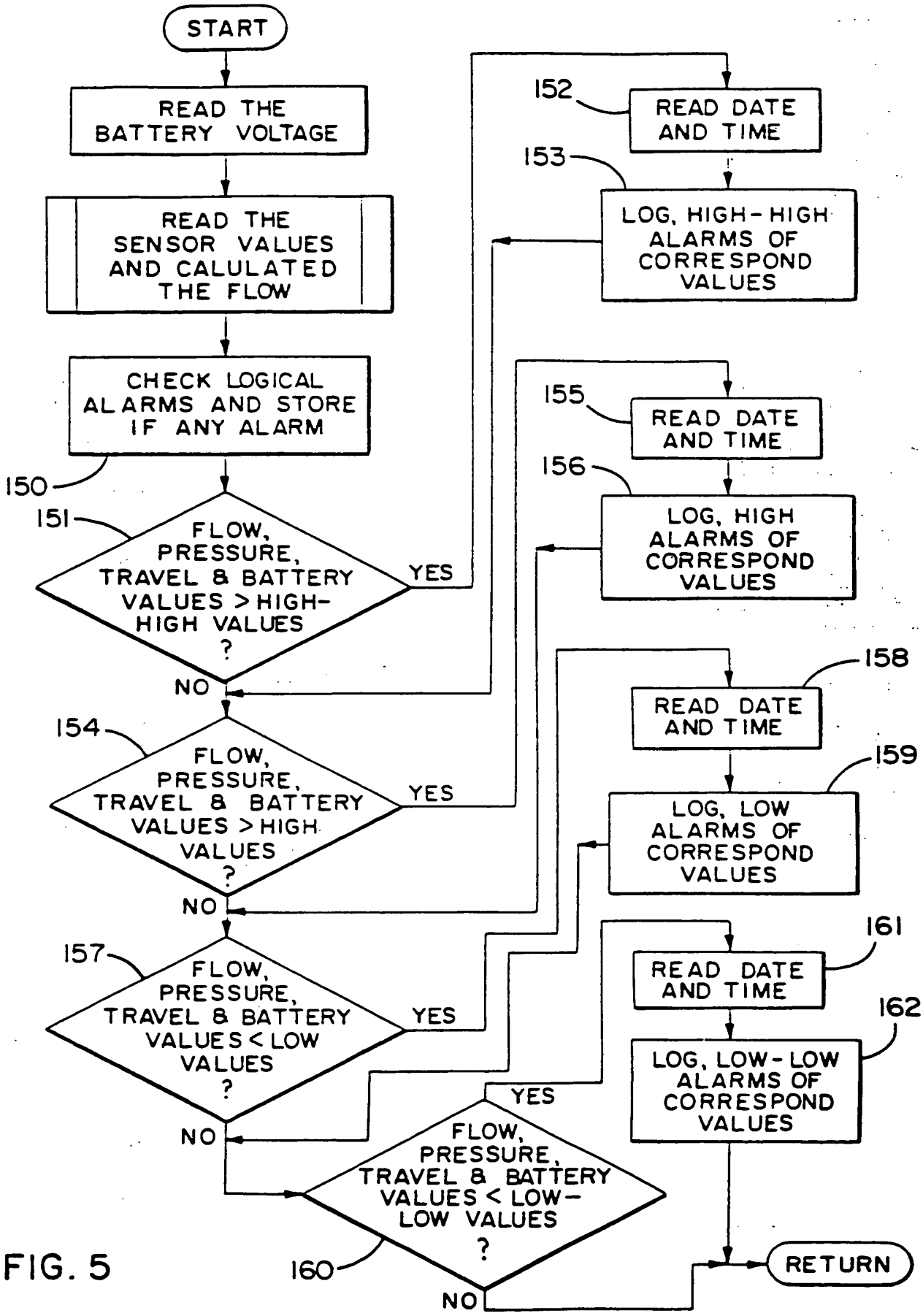

START
READ THE BATTERY VOLTAGE
READ THE SENSOR VALUES AND CALULATED THE FLOW
CHECK LOGICAL ALARMS AND STORE IF ANY ALARM
150
151
FLOW, PRESSURE, TRAVEL & BATTERY VALUES > HIGH-HIGH VALUES ?
YES
NO
152
READ DATE AND TIME
153
LOG, HIGH-HIGH ALARMS OF CORRESPOND VALUES
154
FLOW, PRESSURE, TRAVEL & BATTERY VALUES > HIGH VALUES ?
YES
NO
155
READ DATE AND TIME
156
LOG, HIGH ALARMS OF CORRESPOND VALUES
157
FLOW, PRESSURE, TRAVEL & BATTERY VALUES < LOW VALUES ?
YES
NO
158
READ DATE AND TIME
159
LOG, LOW ALARMS OF CORRESPOND VALUES
160
FLOW, PRESSURE, TRAVEL & BATTERY VALUES < LOW-LOW VALUES ?
YES
NO
161
READ DATE AND TIME
162
LOG, LOW-LOW ALARMS OF CORRESPOND VALUES
RETURN

FIG. 5

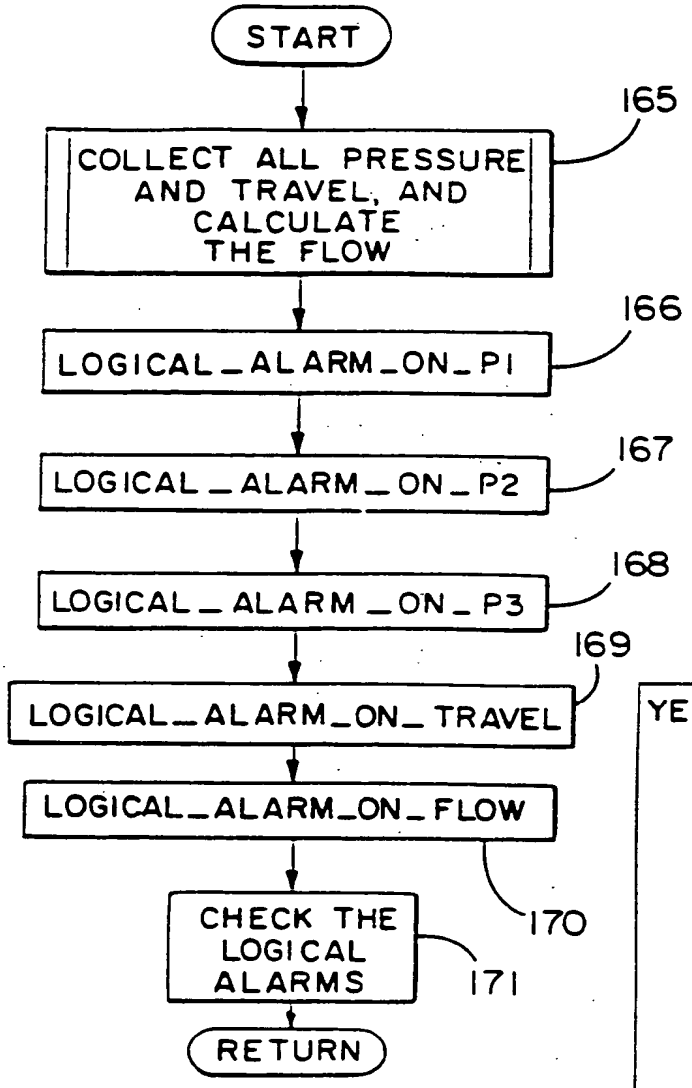

START
165
COLLECT ALL PRESSURE AND TRAVEL, AND CALCULATE THE FLOW
166
LOGICAL_ALARM_ON_P1
167
LOGICAL_ALARM_ON_P2
168
LOGICAL_ALARM_ON_P3
169
LOGICAL_ALARM_ON_TRAVEL
LOGICAL_ALARM_ON_FLOW
170
CHECK THE LOGICAL ALARMS
171
RETURN

FIG. 6

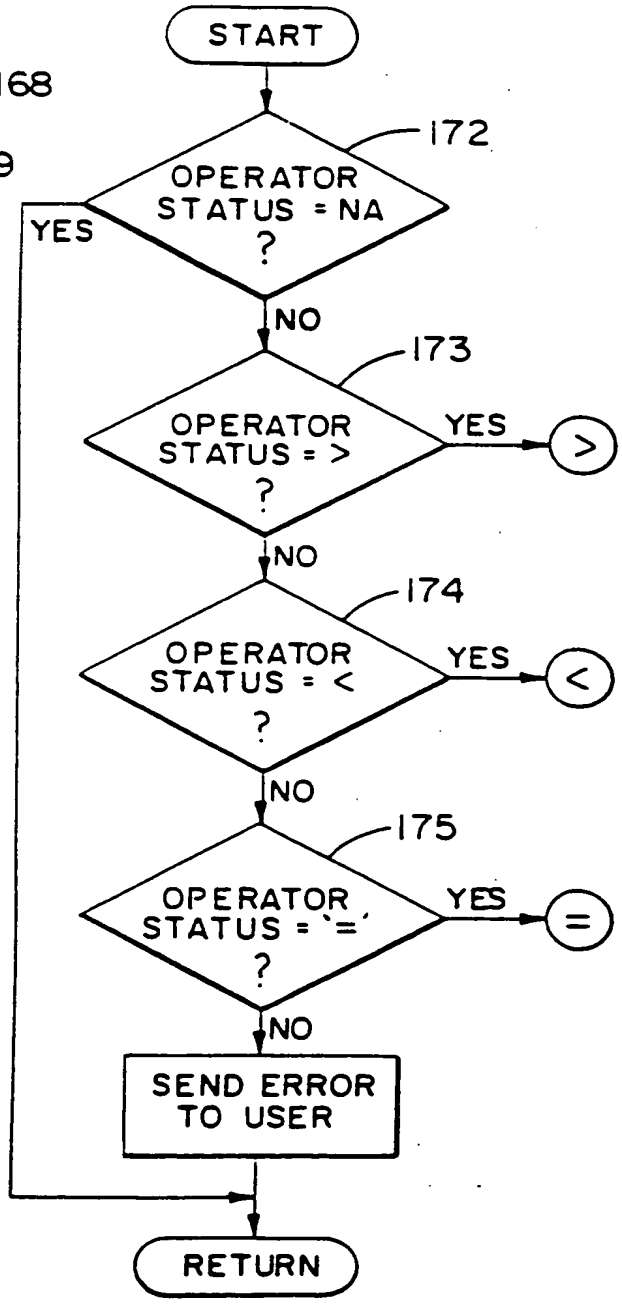

START
172
OPERATOR STATUS = NA ?
YES
NO
173
OPERATOR STATUS = > ?
YES
>
NO
174
OPERATOR STATUS = < ?
YES
<
NO
175
OPERATOR STATUS = '=' ?
YES
=
NO
SEND ERROR TO USER
RETURN

FIG. 7A

FIG. 7B

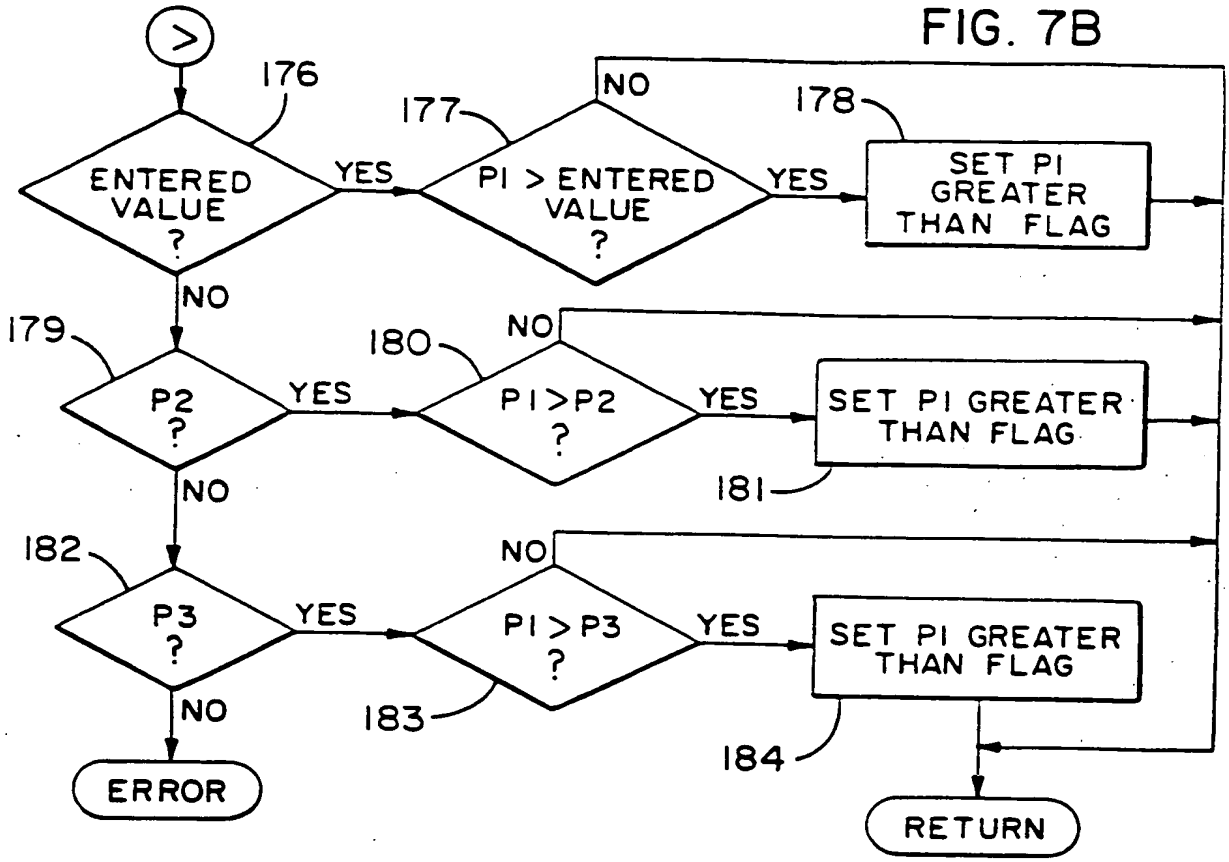
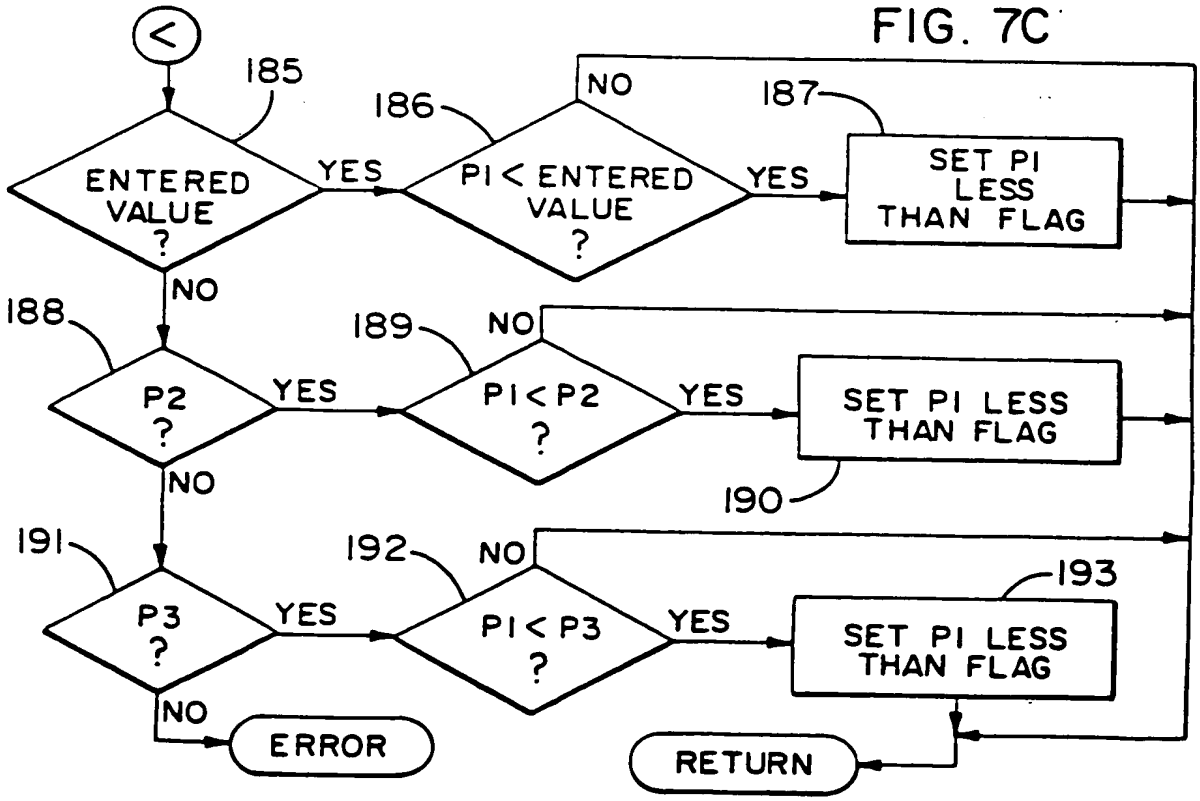

>
176
ENTERED VALUE ?
YES
177
PI > ENTERED VALUE ?
NO
YES
178
SET PI GREATER THAN FLAG
NO
179
P2 ?
YES
180
PI > P2 ?
NO
YES
SET PI GREATER THAN FLAG
181
NO
182
P3 ?
YES
PI > P3 ?
NO
YES
SET PI GREATER THAN FLAG
183
184
NO
ERROR
RETURN

FIG. 7C


<
185
ENTERED VALUE ?
YES
186
PI < ENTERED VALUE ?
NO
YES
187
SET PI LESS THAN FLAG
NO
188
P2 ?
YES
189
PI < P2 ?
NO
YES
SET PI LESS THAN FLAG
190
NO
191
P3 ?
YES
192
PI < P3 ?
NO
YES
193
SET PI LESS THAN FLAG
NO
ERROR
RETURN

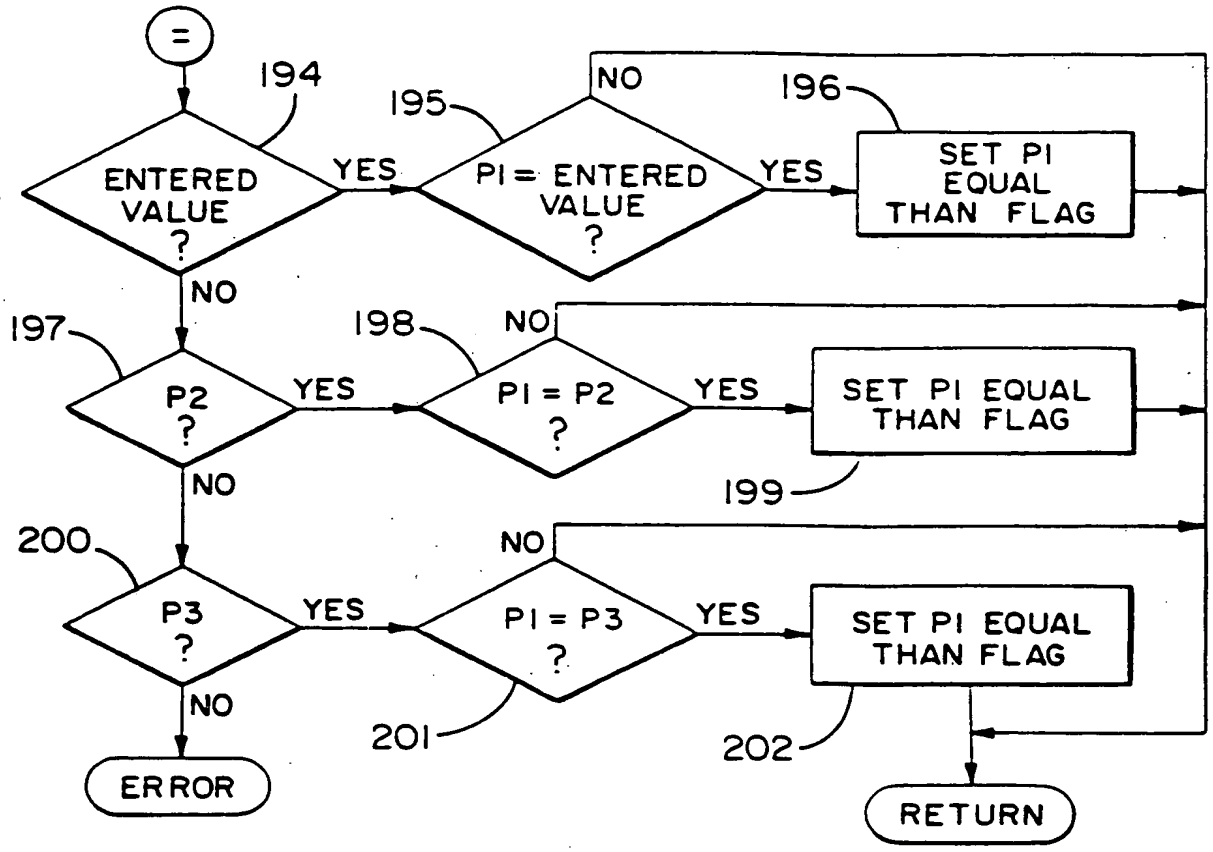

=
194
ENTERED VALUE ?
YES
195
PI = ENTERED VALUE ?
NO
YES
196
SET PI EQUAL THAN FLAG
NO
197
P2 ?
YES
198
PI = P2 ?
NO
YES
SET PI EQUAL THAN FLAG
199
NO
200
P3 ?
YES
PI = P3 ?
NO
YES
SET PI EQUAL THAN FLAG
201
202
NO
ERROR
RETURN

FIG. 7D

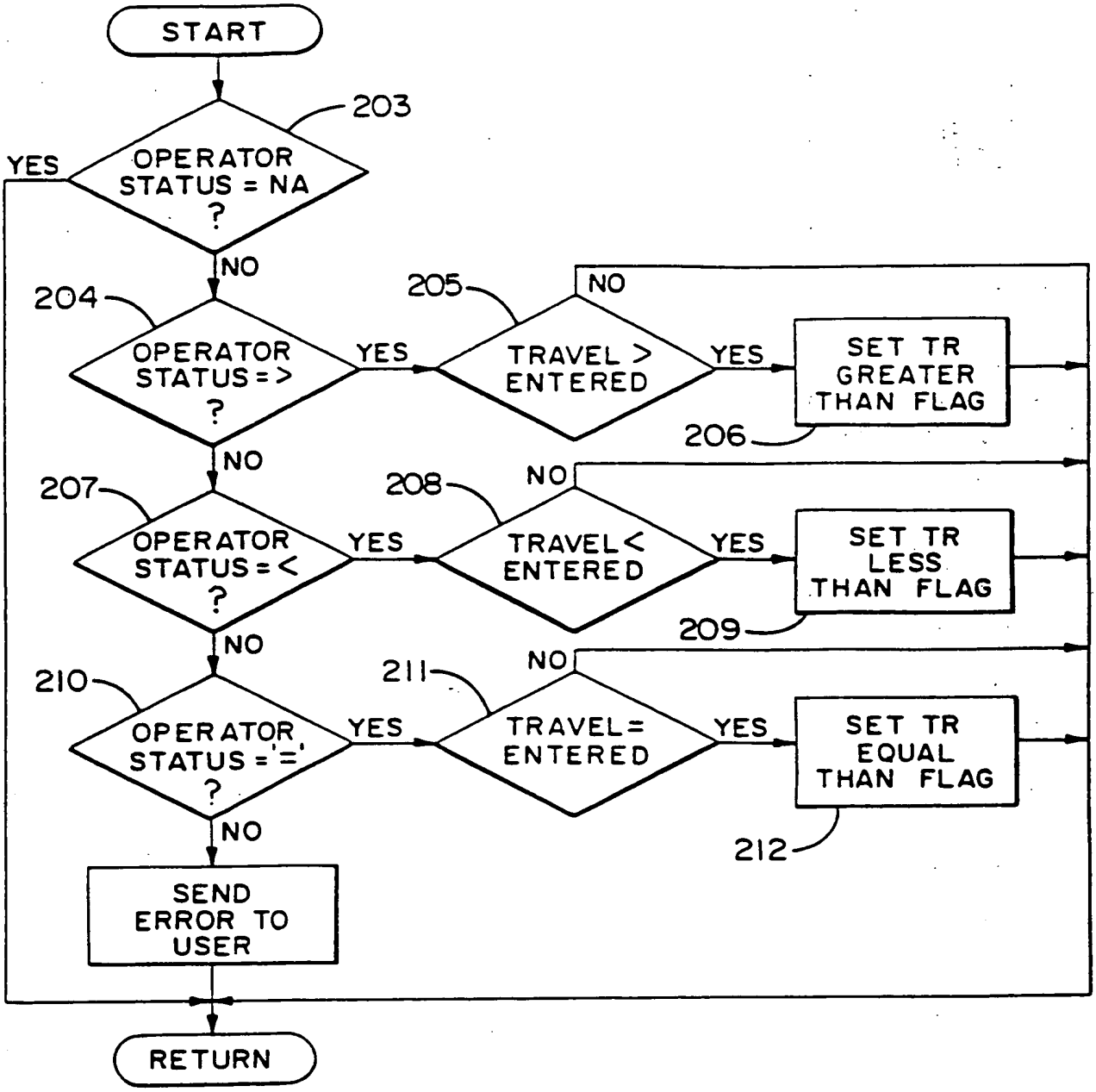
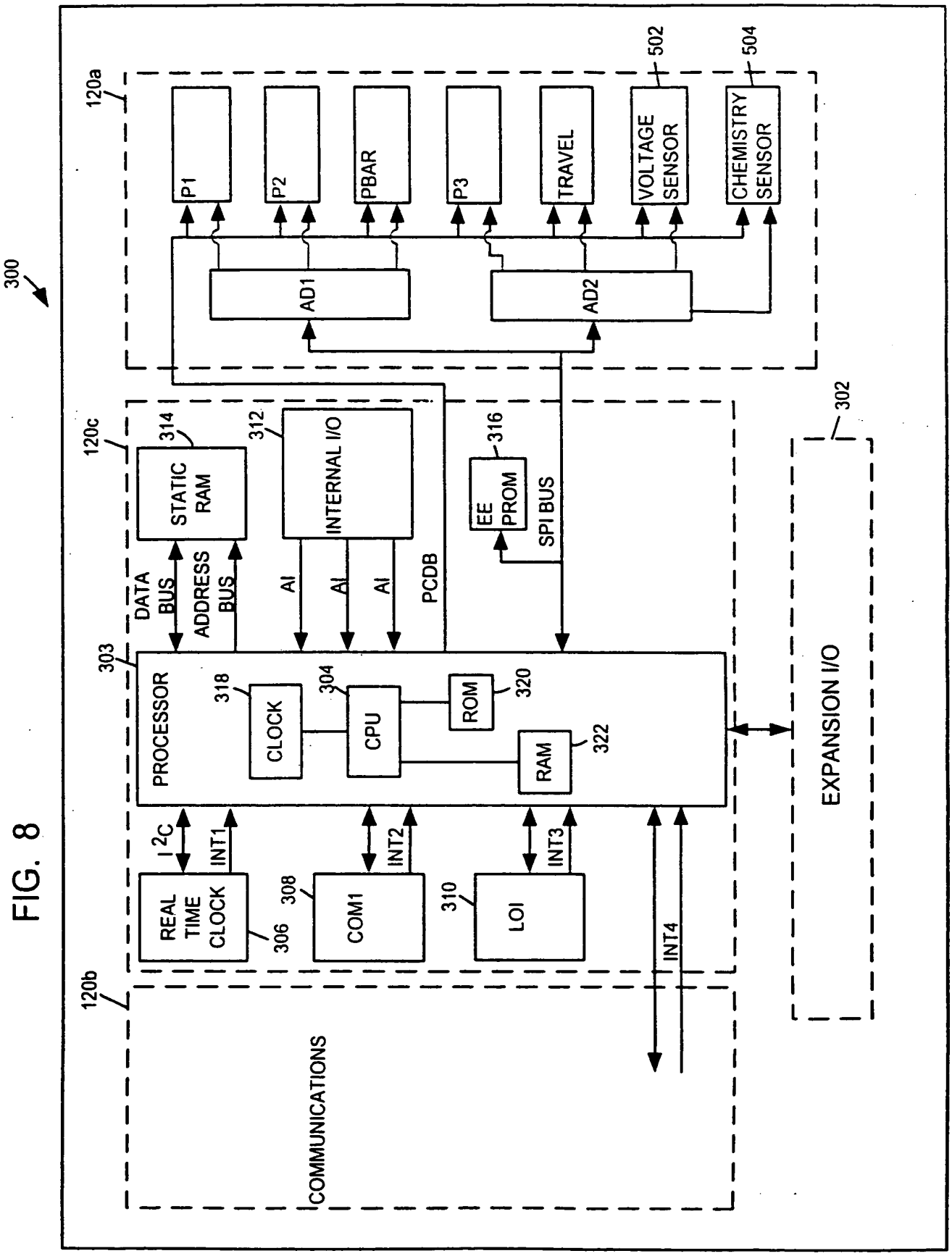

START
203
YES
OPERATOR STATUS = NA ?
NO
204
OPERATOR STATUS = > ?
YES
205
NO
TRAVEL > ENTERED
YES
SET TR GREATER THAN FLAG
206
NO
207
OPERATOR STATUS = < ?
YES
208
NO
TRAVEL < ENTERED
YES
SET TR LESS THAN FLAG
209
NO
210
OPERATOR STATUS = '=' ?
YES
211
NO
TRAVEL = ENTERED
YES
SET TR EQUAL THAN FLAG
212
NO
SEND ERROR TO USER
RETURN

FIG. 7E

FIG. 8


300
120a
P1
P2
PBAR
P3
TRAVEL
VOLTAGE SENSOR
CHEMISTRY SENSOR
502
504
AD1
AD2
120c
314
STATIC RAM
312
INTERNAL I/O
316
EE PROM
SPI BUS
DATA BUS
ADDRESS BUS
AI
AI
AI
PCDB
303
PROCESSOR
318
CLOCK
304
CPU
ROM
320
RAM
322
302
EXPANSION I/O
I2C
INT1
INT2
INT3
INT4
REAL TIME CLOCK
306
308
COM1
310
LOI
120b
COMMUNICATIONS

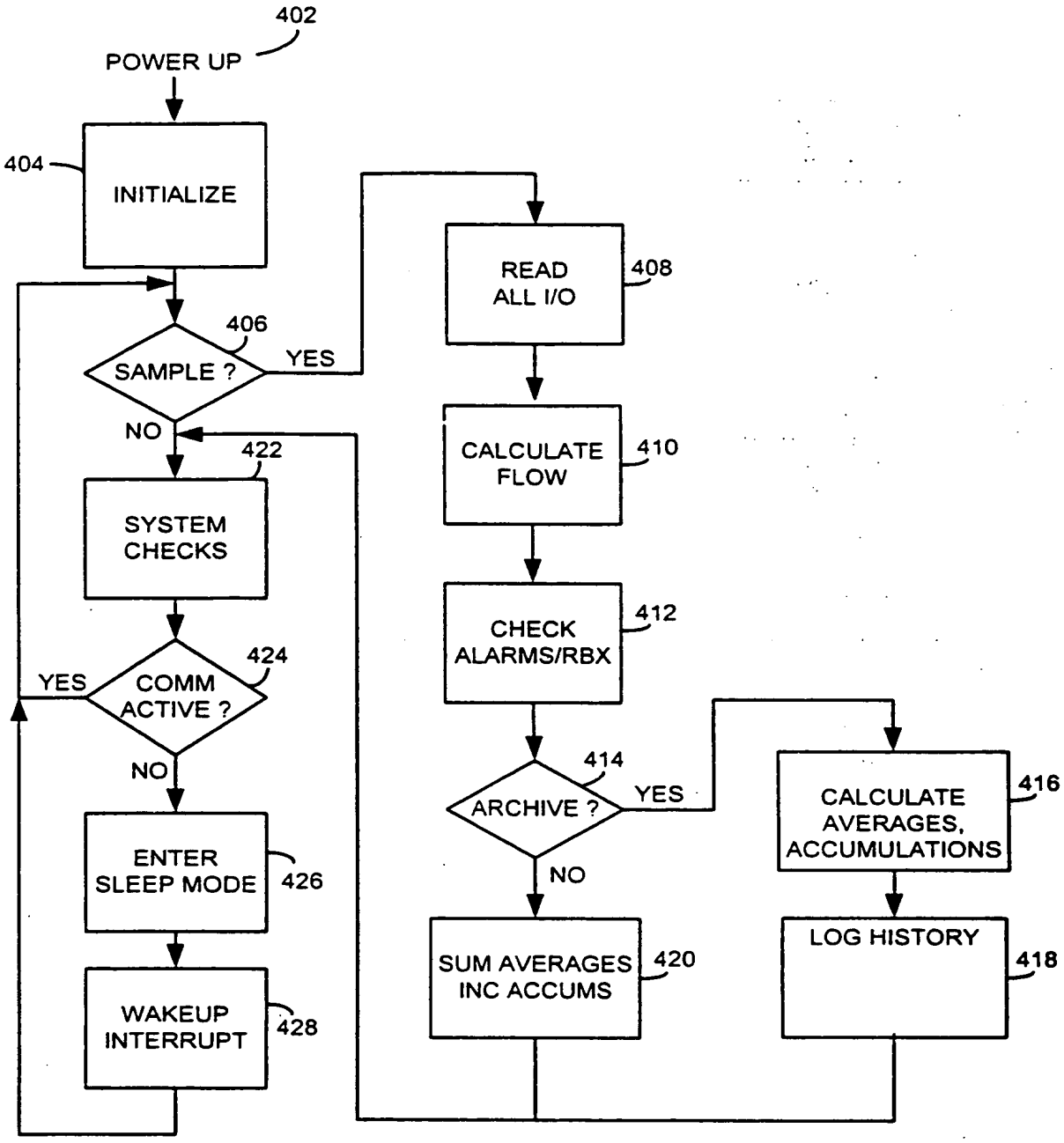

402
POWER UP
404
INITIALIZE
406
SAMPLE ?
YES
NO
422
SYSTEM CHECKS
424
COMM ACTIVE ?
YES
NO
ENTER SLEEP MODE
426
WAKEUP INTERRUPT
428
READ ALL I/O
408
CALCULATE FLOW
410
CHECK ALARMS/RBX
412
414
ARCHIVE ?
YES
NO
SUM AVERAGES INC ACCUMS
420
CALCULATE AVERAGES, ACCUMULATIONS
416
LOG HISTORY
418

FIG. 9

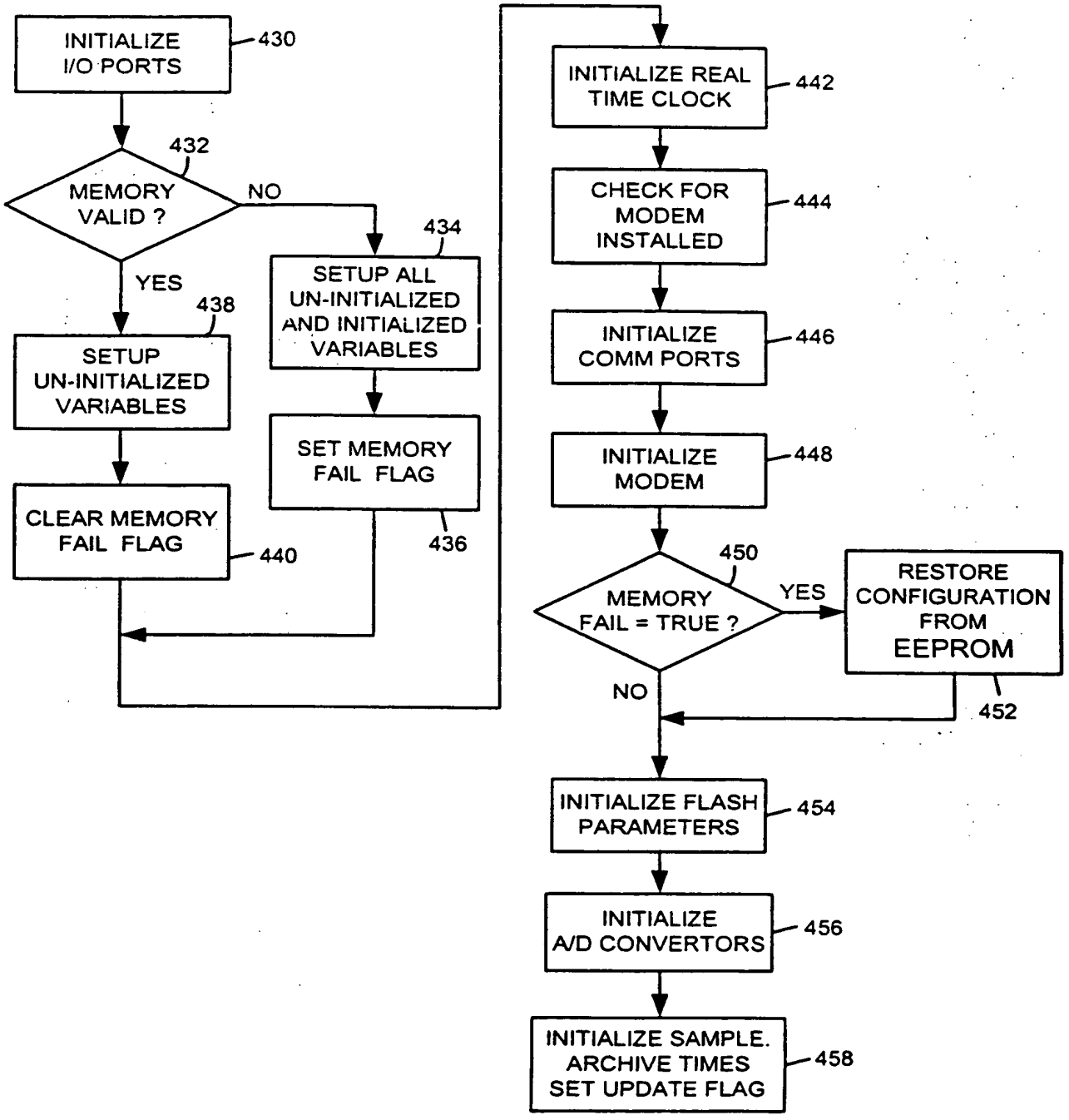

INITIALIZE I/O PORTS
430
MEMORY VALID ?
432
NO
YES
SETUP ALL UN-INITIALIZED AND INITIALIZED VARIABLES
434
SETUP UN-INITIALIZED VARIABLES
438
SET MEMORY FAIL FLAG
436
CLEAR MEMORY FAIL FLAG
440
INITIALIZE REAL TIME CLOCK
442
CHECK FOR MODEM INSTALLED
444
INITIALIZE COMM PORTS
446
INITIALIZE MODEM
448
MEMORY FAIL = TRUE ?
450
YES
RESTORE CONFIGURATION FROM EEPROM
452
NO
INITIALIZE FLASH PARAMETERS
454
INITIALIZE A/D CONVERTORS
456
INITIALIZE SAMPLE. ARCHIVE TIMES SET UPDATE FLAG
458

FIG. 10

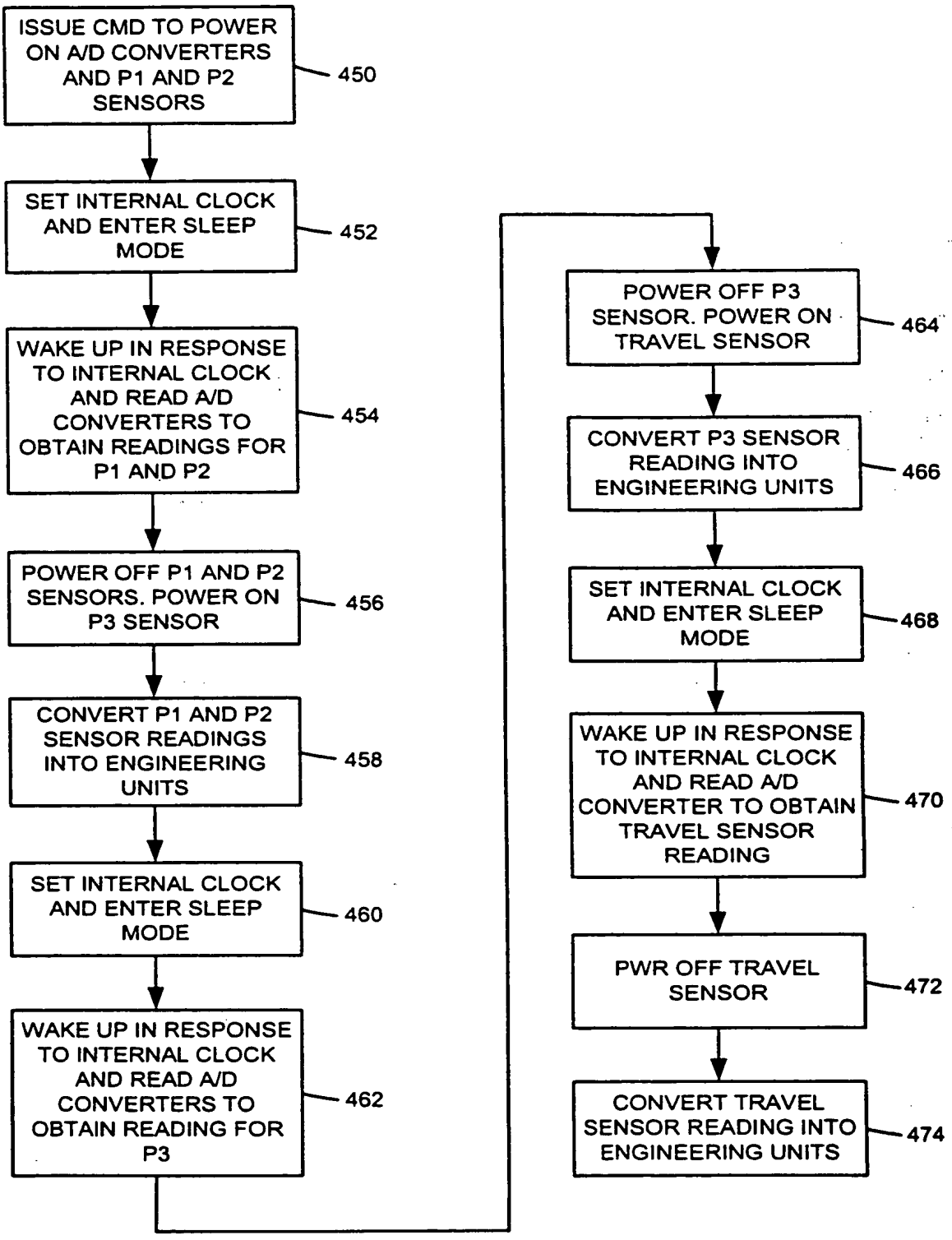

ISSUE CMD TO POWER ON A/D CONVERTERS AND P1 AND P2 SENSORS
450
SET INTERNAL CLOCK AND ENTER SLEEP MODE
452
WAKE UP IN RESPONSE TO INTERNAL CLOCK AND READ A/D CONVERTERS TO OBTAIN READINGS FOR P1 AND P2
454
POWER OFF P1 AND P2 SENSORS. POWER ON P3 SENSOR
456
CONVERT P1 AND P2 SENSOR READINGS INTO ENGINEERING UNITS
458
SET INTERNAL CLOCK AND ENTER SLEEP MODE
460
WAKE UP IN RESPONSE TO INTERNAL CLOCK AND READ A/D CONVERTERS TO OBTAIN READING FOR P3
462
POWER OFF P3 SENSOR. POWER ON TRAVEL SENSOR
464
CONVERT P3 SENSOR READING INTO ENGINEERING UNITS
466
SET INTERNAL CLOCK AND ENTER SLEEP MODE
468
WAKE UP IN RESPONSE TO INTERNAL CLOCK AND READ A/D CONVERTER TO OBTAIN TRAVEL SENSOR READING
470
PWR OFF TRAVEL SENSOR
472
CONVERT TRAVEL SENSOR READING INTO ENGINEERING UNITS
474

FIG. 11

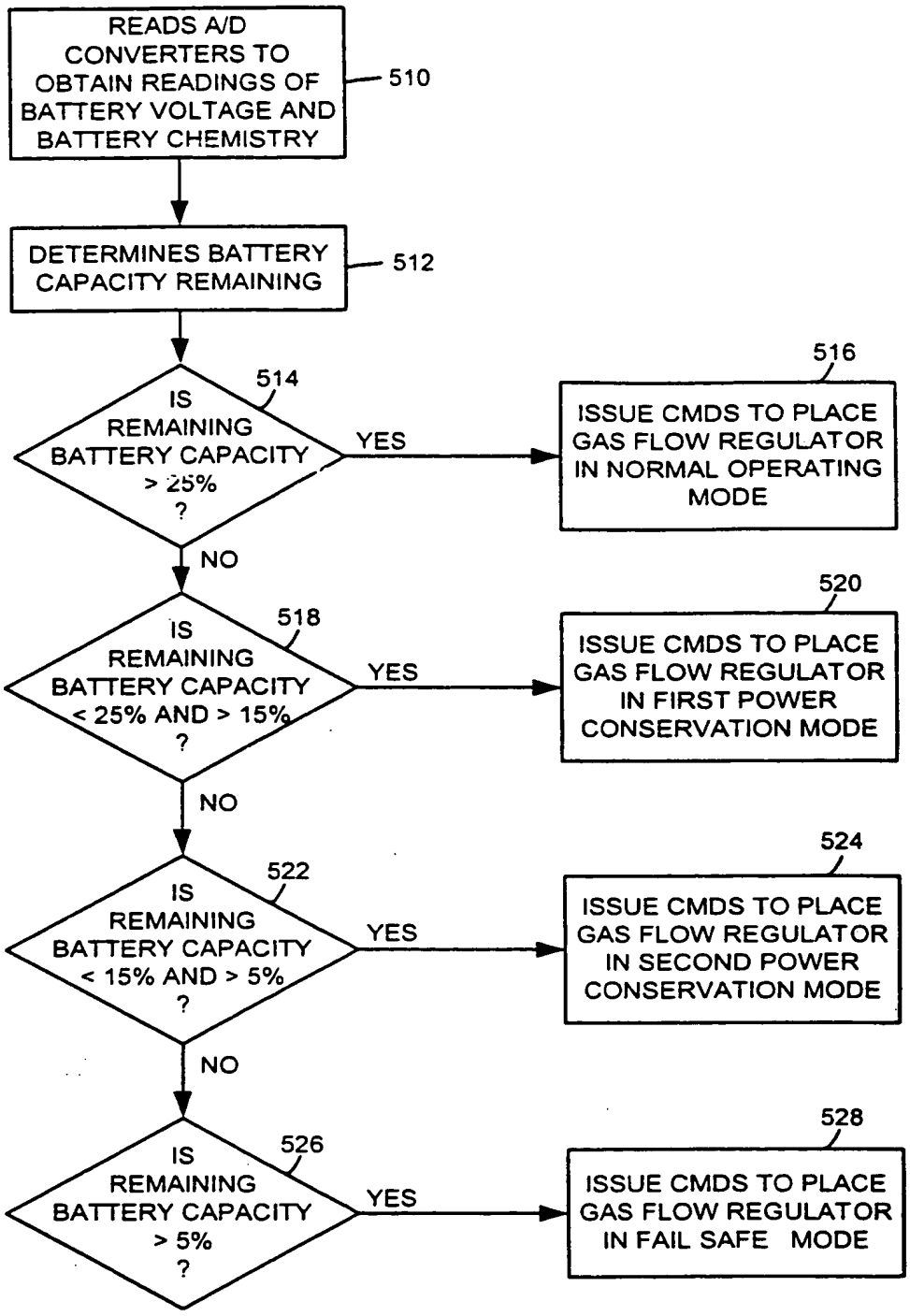

READS A/D CONVERTERS TO OBTAIN READINGS OF BATTERY VOLTAGE AND BATTERY CHEMISTRY
510
DETERMINES BATTERY CAPACITY REMAINING
512
514
IS REMAINING BATTERY CAPACITY > 25% ?
YES
516
ISSUE CMDS TO PLACE GAS FLOW REGULATOR IN NORMAL OPERATING MODE
NO
518
IS REMAINING BATTERY CAPACITY < 25% AND > 15% ?
YES
520
ISSUE CMDS TO PLACE GAS FLOW REGULATOR IN FIRST POWER CONSERVATION MODE
NO
522
IS REMAINING BATTERY CAPACITY < 15% AND > 5% ?
YES
524
ISSUE CMDS TO PLACE GAS FLOW REGULATOR IN SECOND POWER CONSERVATION MODE
NO
526
IS REMAINING BATTERY CAPACITY > 5% ?
YES
528
ISSUE CMDS TO PLACE GAS FLOW REGULATOR IN FAIL SAFE MODE

FIG. 12

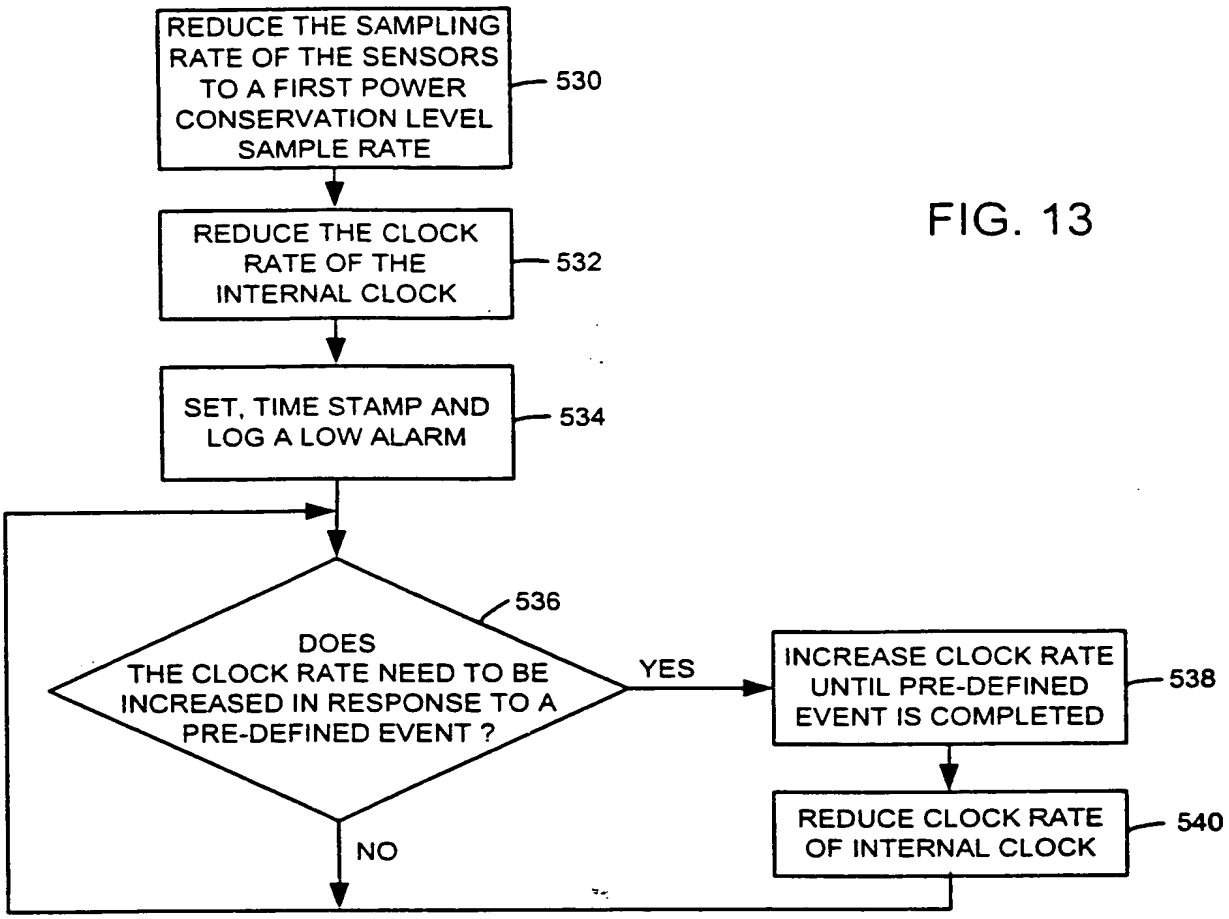

REDUCE THE SAMPLING RATE OF THE SENSORS TO A FIRST POWER CONSERVATION LEVEL SAMPLE RATE
530
REDUCE THE CLOCK RATE OF THE INTERNAL CLOCK
532
SET, TIME STAMP AND LOG A LOW ALARM
534
536
DOES THE CLOCK RATE NEED TO BE INCREASED IN RESPONSE TO A PRE-DEFINED EVENT ?
YES
INCREASE CLOCK RATE UNTIL PRE-DEFINED EVENT IS COMPLETED
538
REDUCE CLOCK RATE OF INTERNAL CLOCK
540
NO

FIG. 13

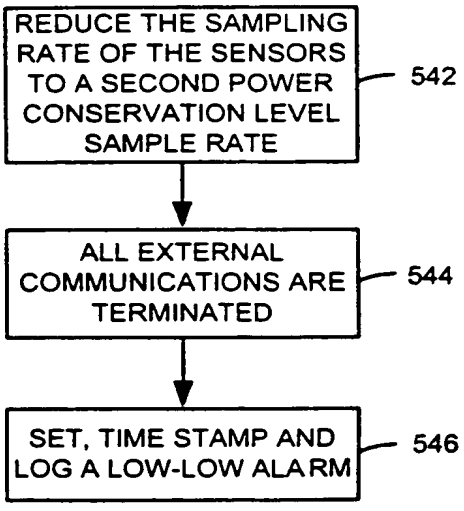

REDUCE THE SAMPLING RATE OF THE SENSORS TO A SECOND POWER CONSERVATION LEVEL SAMPLE RATE
542
ALL EXTERNAL COMMUNICATIONS ARE TERMINATED
544
SET, TIME STAMP AND LOG A LOW-LOW ALARM
546

FIG. 14

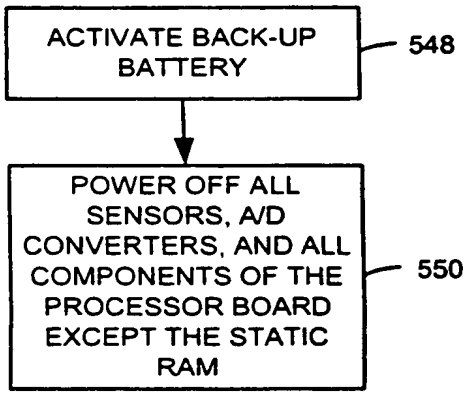

ACTIVATE BACK-UP BATTERY
548
POWER OFF ALL SENSORS, A/D CONVERTERS, AND ALL COMPONENTS OF THE PROCESSOR BOARD EXCEPT THE STATIC RAM
550

FIG. 15